Using time-series approaches to improve Landsat's characterization of landscape dynamics

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Motivation

- Landsat data continuity, global consistency, and integrity grow increasingly critical under increasing population and climate change pressures
- Data richness our greatest asset and also our greatest challenge

It is critical in the LDCM era to characterize land surface change with approaches that are interpretable yet rich, globally consistent yet flexible, and founded on the integrity of Landsat yet amenable to augmentation by other sensors.

Key objectives

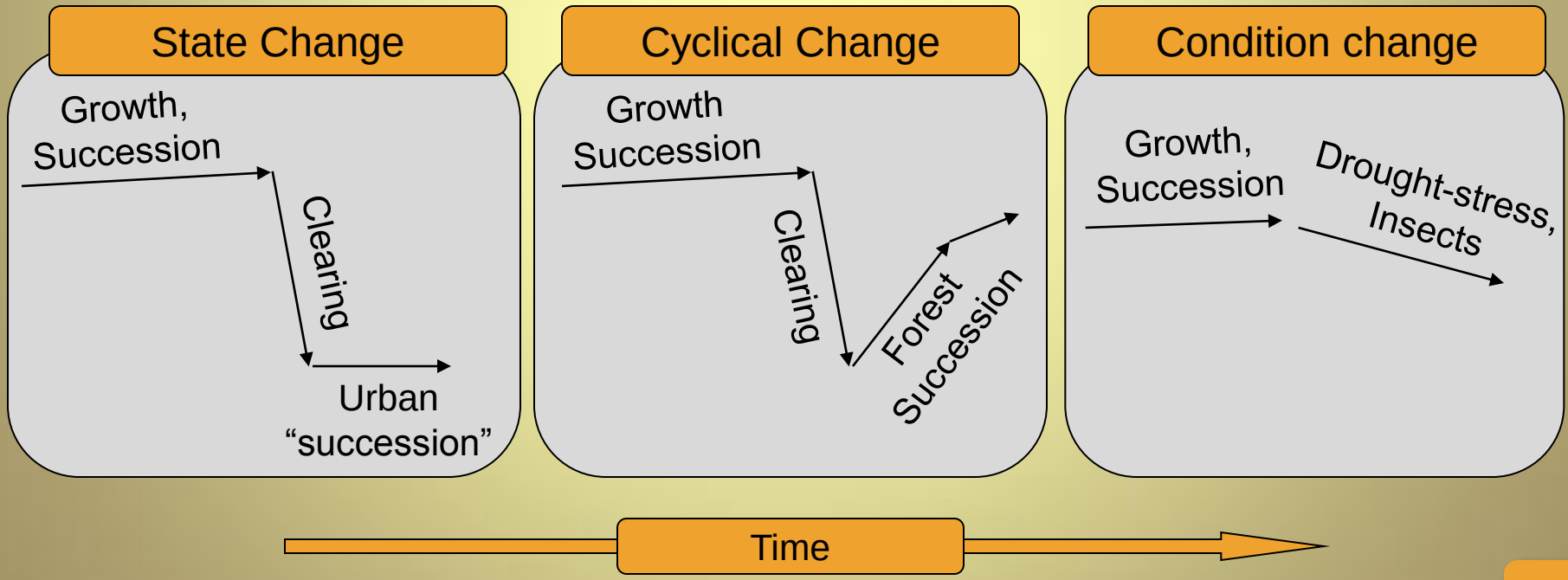
- Develop integrated framework to consistently characterize land-surface dynamics across major biomes and land use regimes
  - Change detection, change attribution, yearly land cover mapping
- Evaluate how data availability and consistency affect methods
  - Data-withholding
  - Integration of other sensors
- Outreach
  - Leverage relevance of Landsat change at local level to engage science and non-science communities

Core issue

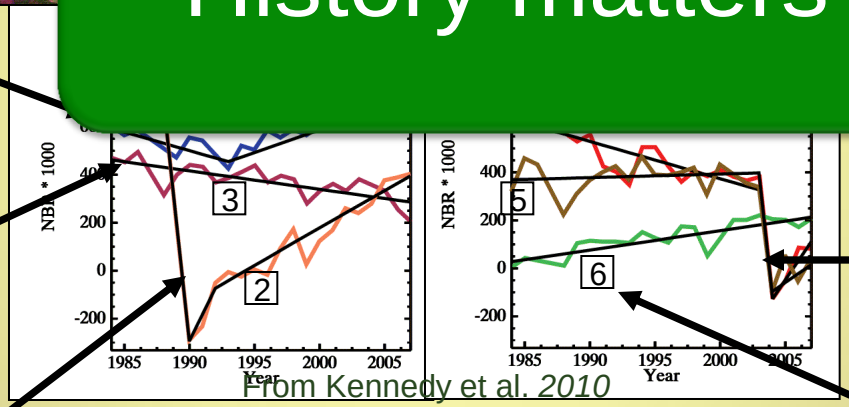
- Generalized detection vs. localized attribution
  - Land cover dynamics developed from spectral information alone
  - Land function dynamics developed through integration of local knowledge developed in cooperation with collaborators

Analytic strategy

- Treat satellite record as long time-series capture of land-surface processes
- For each geographic location, adopt a "life history" approach to search for signal
- Explicit recognition of core land processes



Life histories: Trends and critical events



From Kennedy et al. *2010*

History matters

1: Insect, then regrowth

2: Harvest, then regrowth

3: Insect-related mortality

4: Insect, then fire

5: Growth, then fire

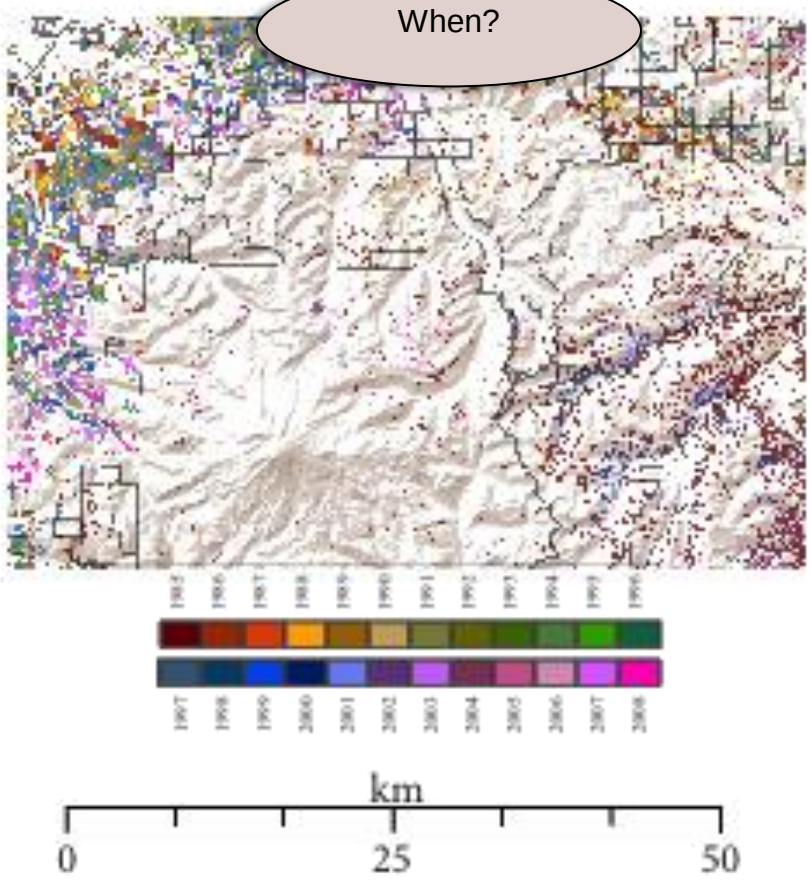
6: Growth

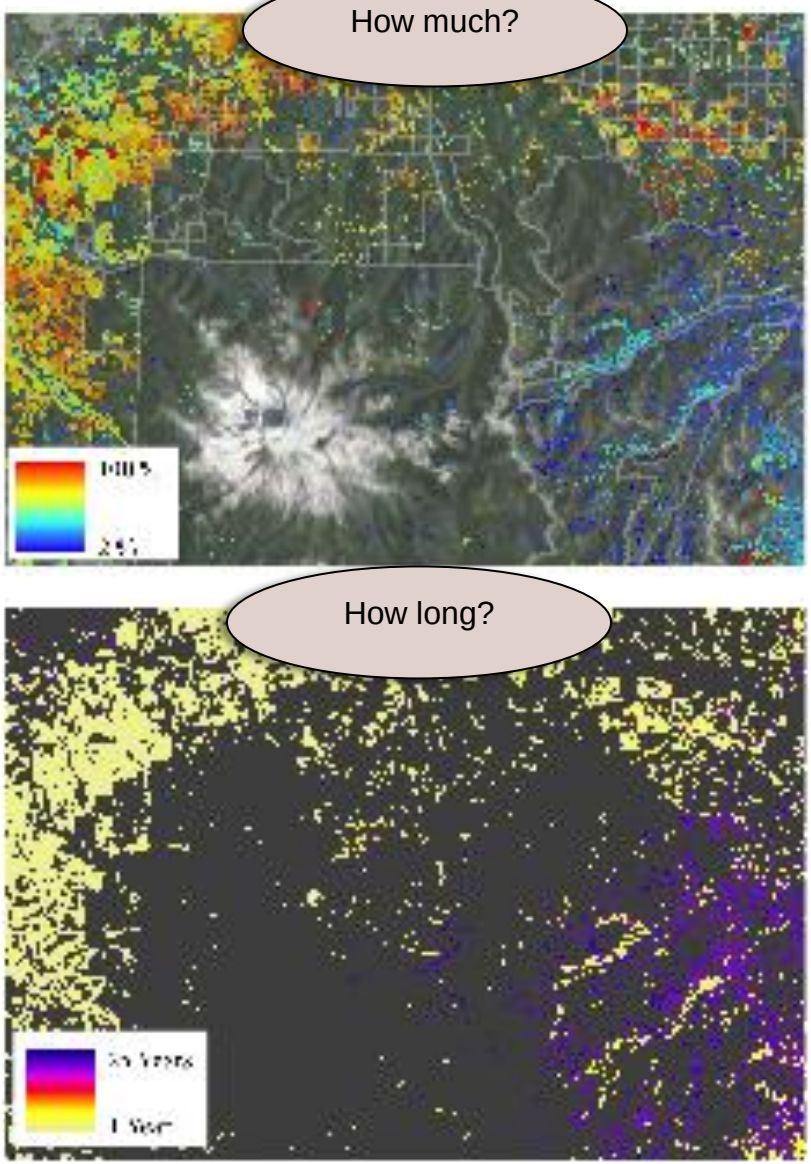
Examples from just six pixels in a relatively small landscape in Oregon show how much change occurs on landscapes

Key benefits to segmentation strategy

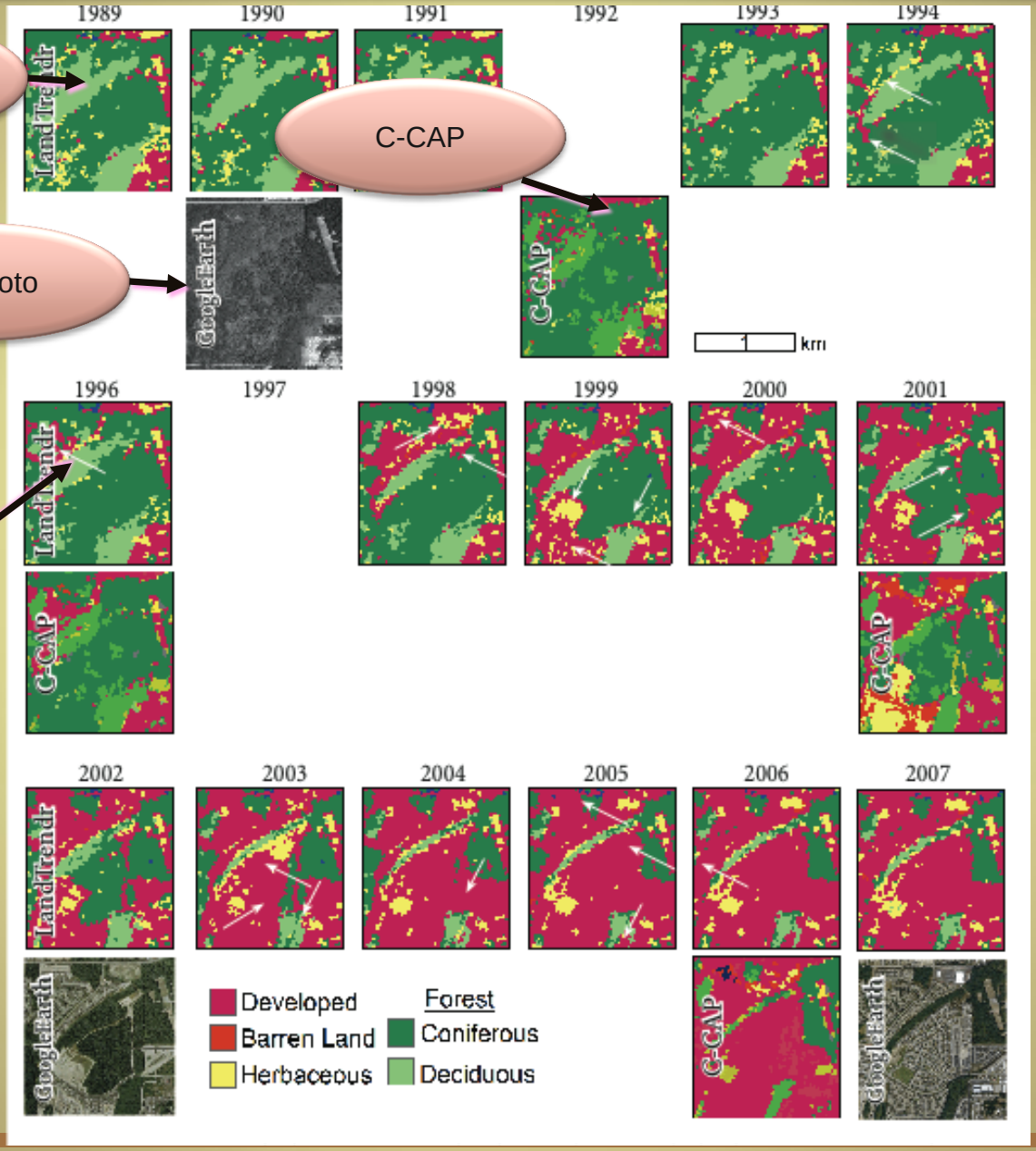
- Simplification
  - Distillation to core life history database
- Noise removal
  - Allows construction of "noise-free" dataset
- Symbolic representation of processes regardless of timing
  - The same "shape" represents similar process sequence, regardless when it happens
- Flexible capture of diverse processes
  - With one pass, capture both trends and events

Mapping trends and events





Yearly land cover mapping



Visualizations

- Noise-removal allows for smooth animations of time-series
- See:

http://svs.gsfc.nasa.gov/vis/a000000/a004000/a004013/

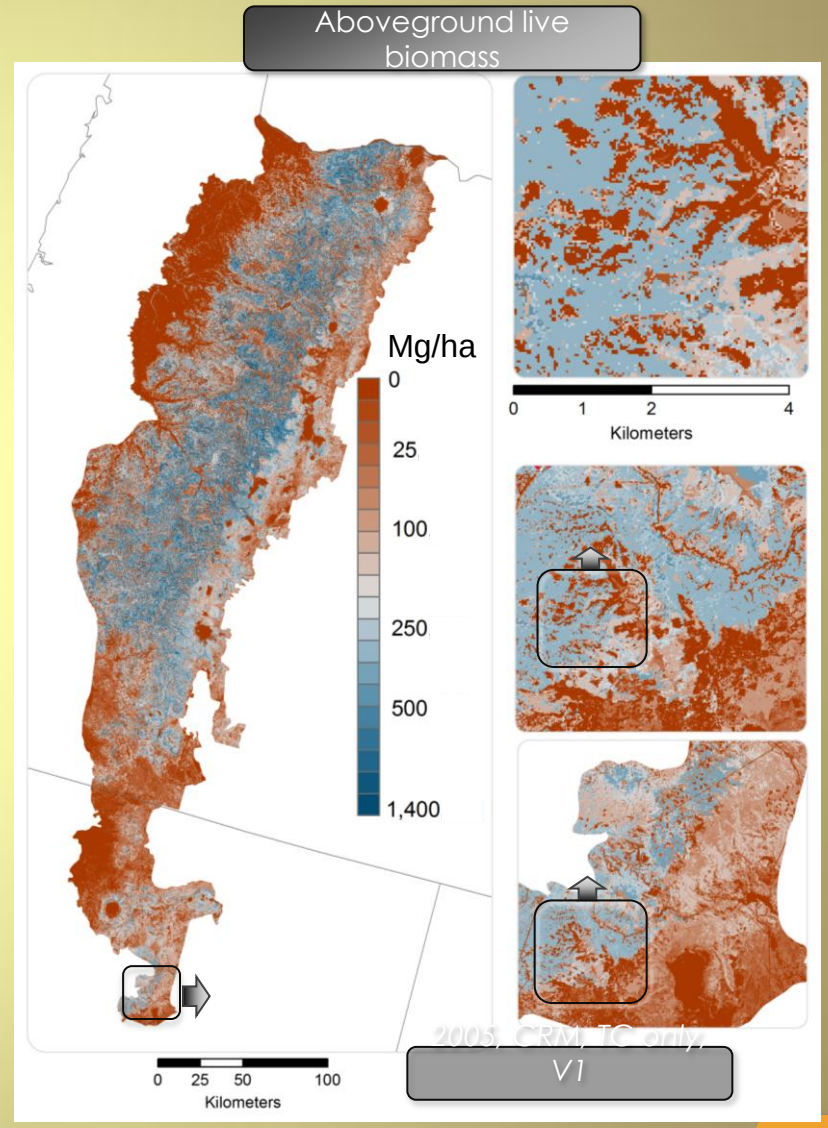
http://svs.gsfc.nasa.gov/vis/a000000/a004000/a004012/

Product: Yearly live biomass

Landsat Time Series → Landtrendr → Stable yearly satellite data

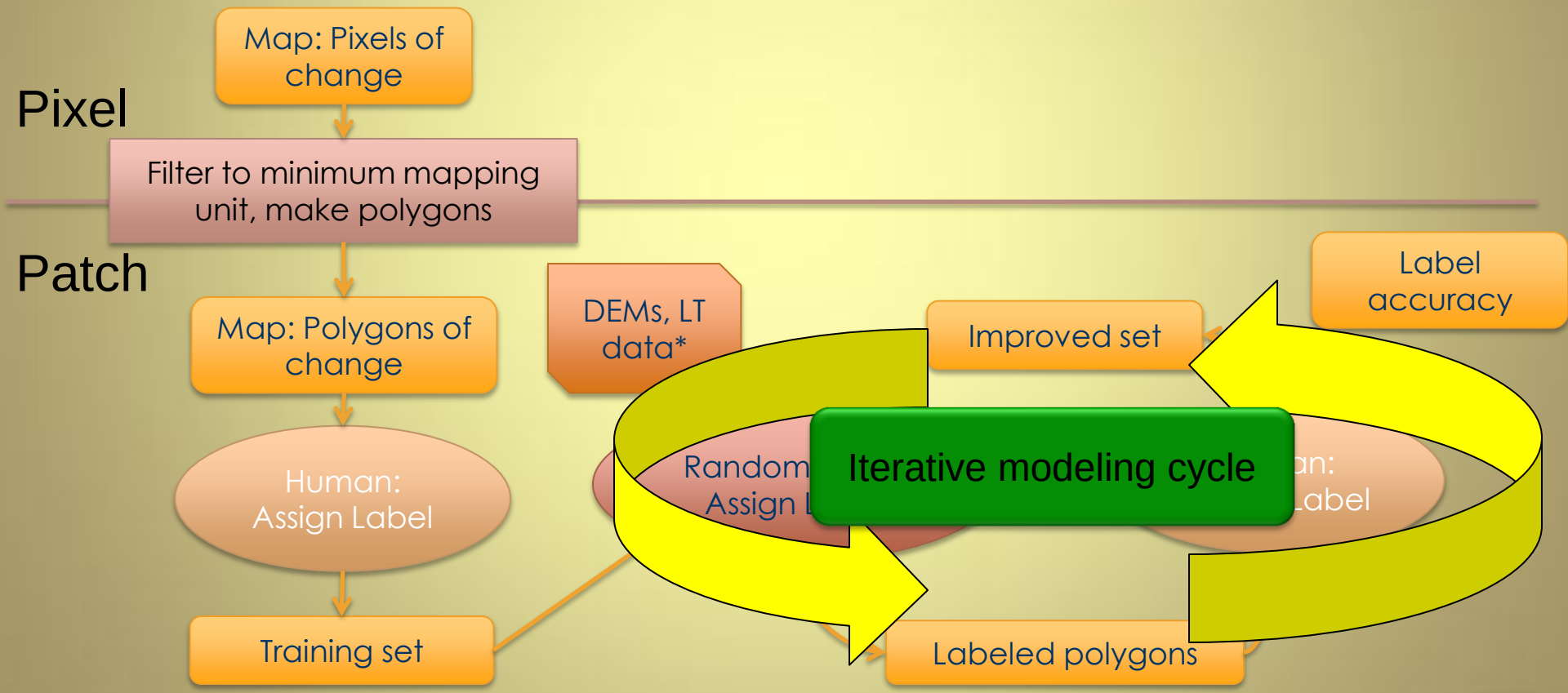
FIA plots + satellite + environmental data → GNN → Map linking each pixel to an FIA Plot

FIA plot data → Allometric Equation → Map of biomass, etc.

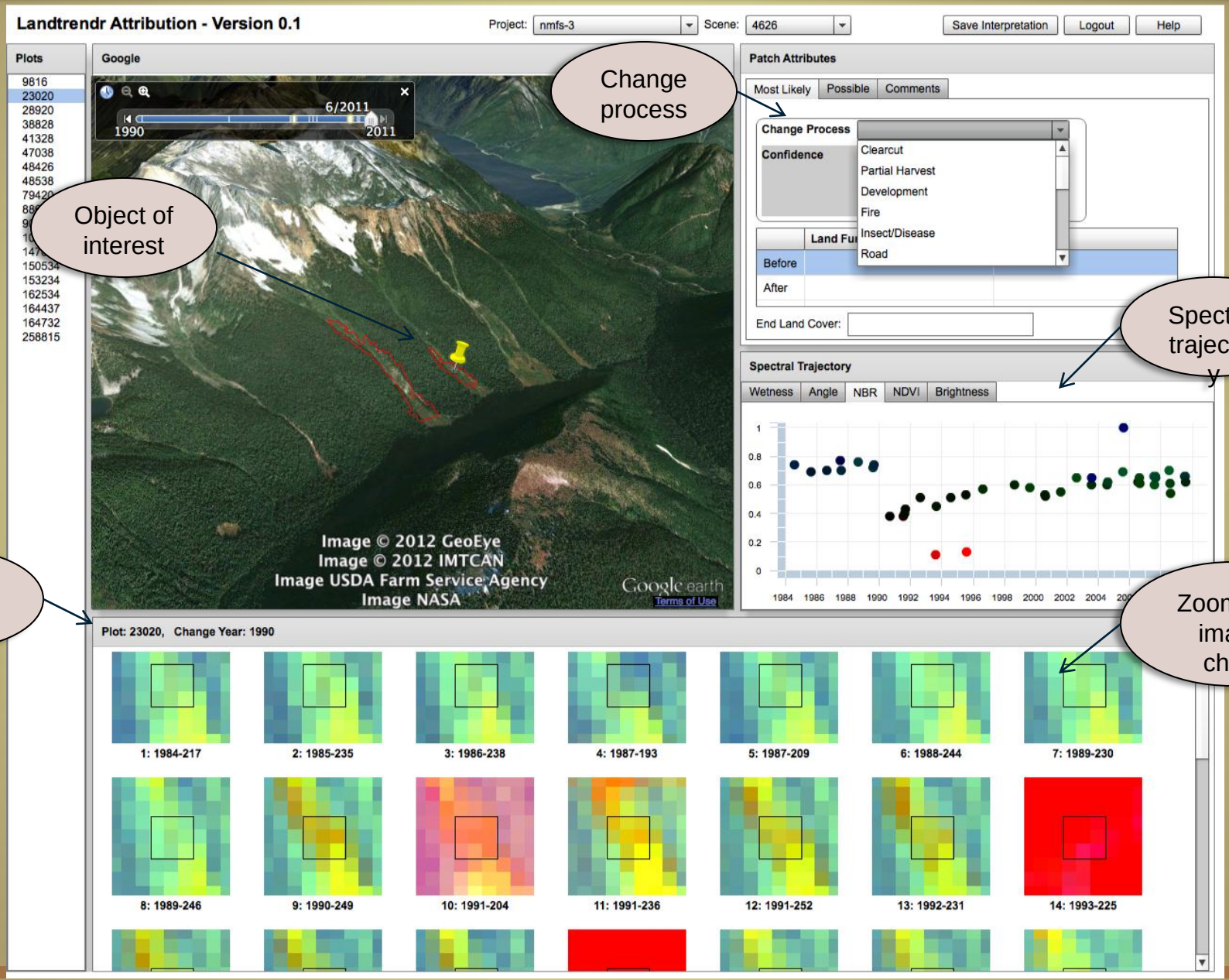


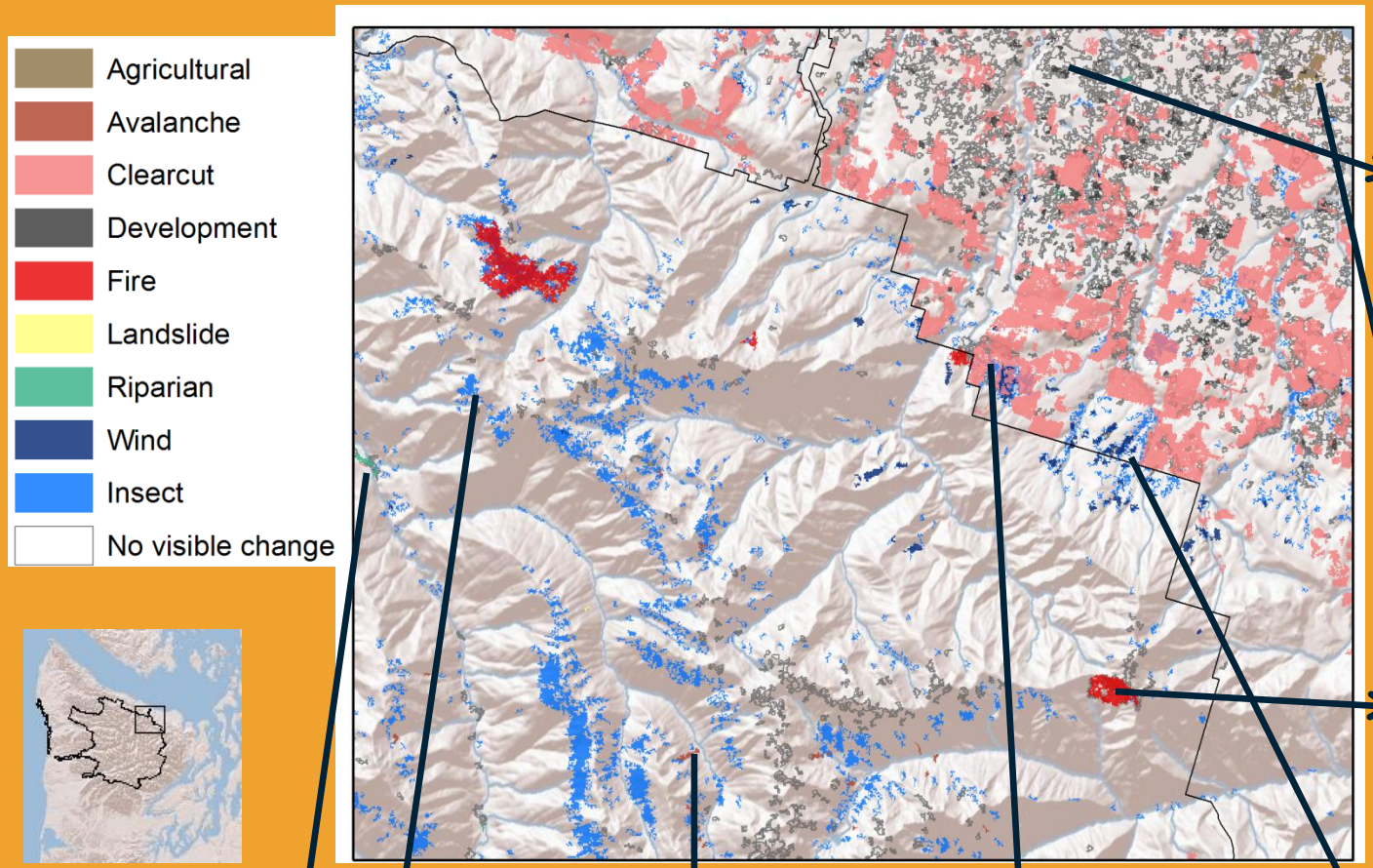
Further distillation: Pixel to patch

- Agents of change must be attributed at patch, not pixel scale



Attribution interface: Web-based

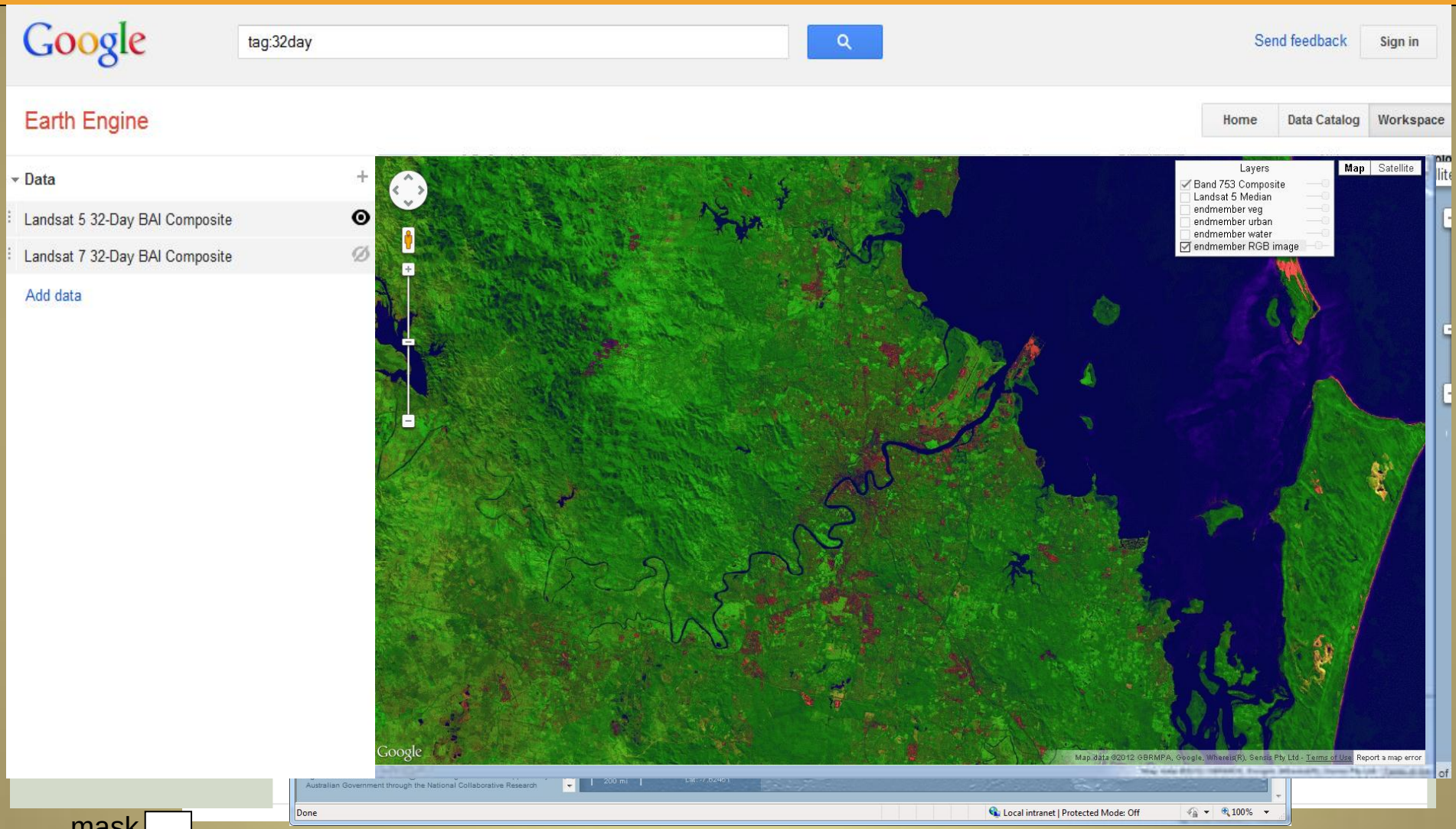



Agricultural
Avalanche
Clearcut
Development
Fire
Landslide
Riparian
Wind
Insect
No visible change
Development
Agriculture
Fire
Fluvial erosion
Balsam woolly adelgid
Avalanche
Clearcut
Windthrow

Key questions:

- How generalizable are:
  - The methods?
  - The symbolic representations?
  - The spectral depiction of land cover?
- How do data availability and consistency affect the answers to those questions?
- How can local user and science communities utilize and improve land cover characterization?

Integrating field data, satellite image data and models: VEGETATION COVER

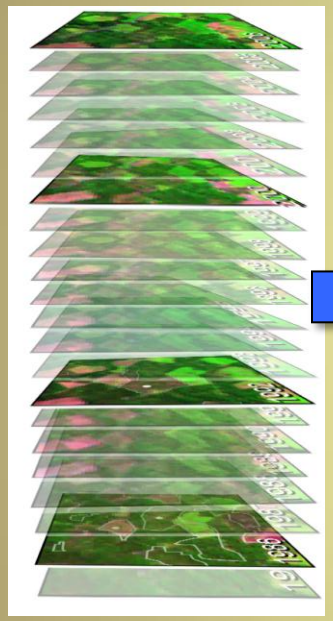


mask

Summary

- Dynamics:
  - Represent landscape processes symbolically
  - Cast in terms that are generalizable….
  - But specify using local and collaborator knowledge
- Methods
  - Test globally
  - Incorporate other sensors
- Outreach
  - Leverage Landsat's legacy to engage science and user communities

Stepping back



Computational science

Remote sensing science

Land surface science

Interpretation

Users

Improved interpretation

A better world

Thank you.

Credits to: Zhiqiang Yang, Warren Cohen, Justin Braaten, Janet Ohmann, Matt Gregory, Heather Roberts, Peder Nelson, Eric Pfaff, Garrett Meigs